MONTHLY LETTER REPORT NO. 9

SPO 26453 (Gems)

Report Period: March 1, 1965 to April 1, 1965

1.0 SUMMARY

Most of the Gem Instrument accessories and the preliminary work on the diagnostic Gem set was completed as scheduled. Functional tests performed with the Gem Instrument resulted in a few minor modifications. Presented in this Monthly Report are the parameters of the diagnostic Gem set to be fabricated during the month of April.

2.0 PROGRESS REPORT ON ACTIVITIES DURING MARCH BY TASK

2.1 Gem Instrument

The instrument was given a functional check. Among the items tested and calibrated were the carriage postion, the exposure meter, uniformity of exposure over the film format, contact of the transparency with unexposed film, and possible light leaks and reflections. A few modifications were made to eliminate light leaks and reflections. The photo cell employed in conjunction with the light meter was relocated in order to obtain an adequate light signal.

2.2 Gem Instrument Accessories

Work in this area progressed better than satisfactory. All the accessories essential to the production of the diagnostic Gem set have been fabricated. Included in the list of accessories completed this past month are two type scene Gem masters and variable transmission spread function masks in two sizes. The scene content of one master consists of an air field with various type planes, aircraft parts, cars, and building. The other master is a scene of an urban area with houses, cars, trees, and light industrial building. The master containing the air field will be utilized in the diagnostic set. A photographic edge and step tablet were made and will be positioned adjacent to the scene for evaluation purposes. Three methods of generating variable transmission spread function masks were investigated several months ago. The methods investigated were a variable transmission, coating process; a photographic process; and a variable density, glass cutting process. The first of these three processes was eliminated because of the high cost and the uncertainty in the control of the coating.

We originally attempted to construct a gaussian mask out of variable density filter glass. Early in this effort, it became apparent that the fabrication costs and time would far exceed what we had anticipated. Consequently, we abandoned this approach and proceeded to make the variable transmission mask photographically. A camera was used to photograph a variable area gaussian mask while it rotated in our prototype Gem Maker. The negative was processed and used to produce a positive transparency wherein the cascaded processing characteristic resulted in an approximately linear relationship between the exposure of the negative and the transmittance of the positive. A plot of normalized transmittance versus distance is presented in Figure I. As can be seen, this spread function is a good approximation of a gaussian light distribution.

2.3 Diagnostic Gem Set

The generation of a diagnostic Gem set will commence during the first week of April. Late delivery of film delayed preliminary calculations involving the film characteristic curve. All other parameters pertaining to the simulation process have been established.

A set of 36 Gems shall be prepared. Each Gem will represent a 6 times enlargement of a camera negative, on type 4404 film, having a scale factor 1:36,000. A general description and detailed specifications are given below.

a. Size: Each Gem shall be a negative transparency measuring 1 7/8" x 2 3/4" less a 3/8" x 2" area to be used for control purposes.

b. Material: Each Gem shall be made on type 8403 film.

c. Processing: Each Gem shall be processed with the objective of achieving a cascaded gamma of 2.3.

This value of gamma may be lower because of the film developer combination and other influencing factors.

d. Scene Content: Scene content described in section 2.2

e. Granularity: Each Gem shall have a $\sigma(D) = 0.14$ at a net density of 1.0. The granularity is actually derived from the use of type 8403 film.

f. Haze: The Gem shall represent haze modulation reductions of 8, 35, 55, and 75%.

g. Exposure: The three levels of relative exposure simulated are normal, one f-stop under, and one f-stop over.

h. Modulation Transfer Function: The three modulation transfer functions shall be approximately gaussian in shape and have 0.01 modulation at spatial frequency values of 8, 16, and 25 1/mm.

3.0 PROJECTED ACTIVITIES FOR MONTH OF APRIL

3.1 Diagnostic Gem Set

The Gem set is scheduled for completion by the end of April.

3.2 Project Report

Work will begin on the preparation of the project summary report during April.

STATINTL

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Project Engineer

STATINTL

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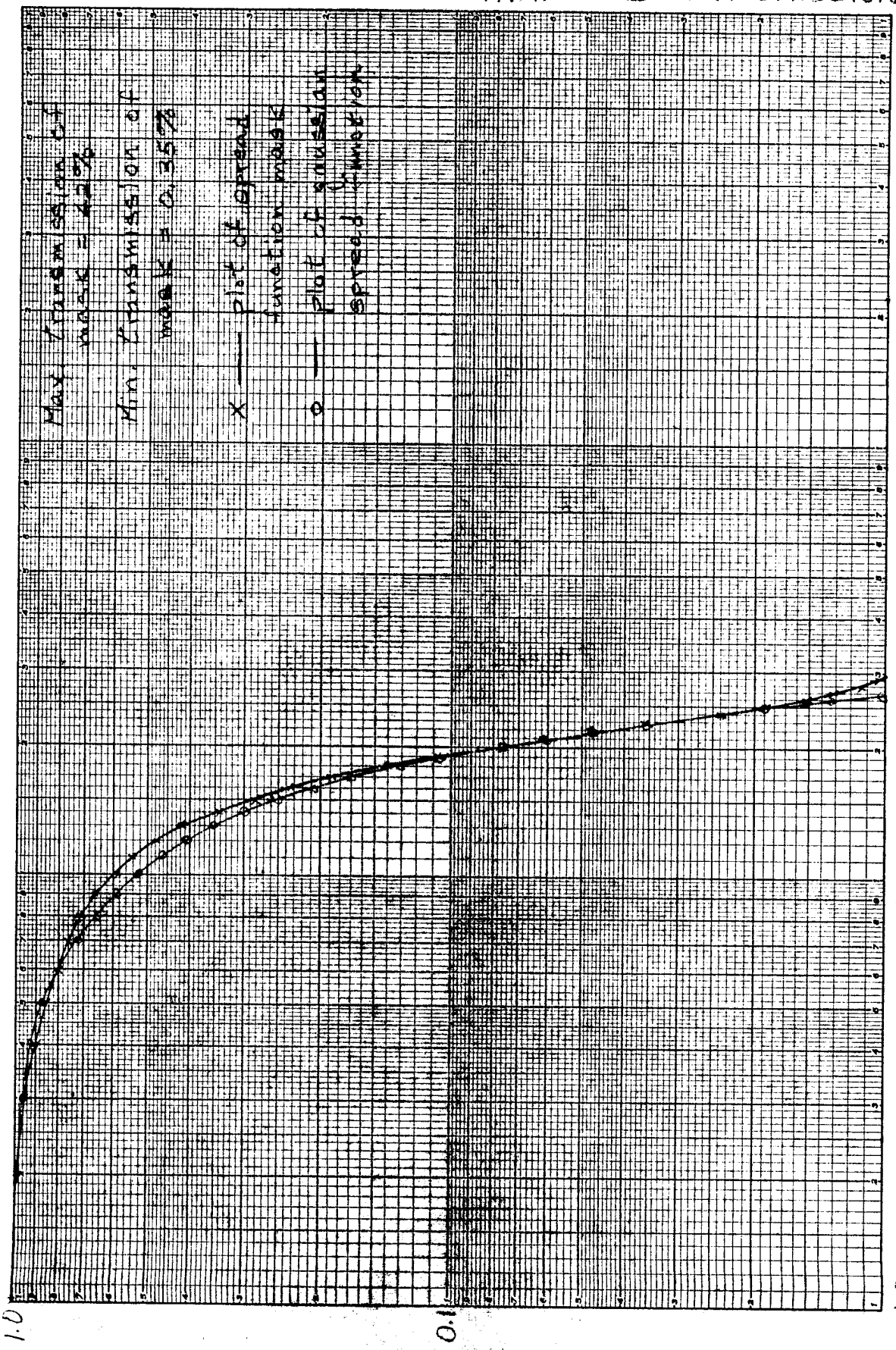
Program Manager

JFC/cam

FIGURE 1 PLOT OF VARIABLE TRANSMISSION MASK



Progress Report No. 9, Study No. 1

SPO 26451 (Edges)

Report Period: March 1965

1.0 SUMMARY

During March this effort has proceeded in a satisfactory manner. The digitizing equipment has been installed on the microdensitometer and operates satisfactorily. The microdensitometer correction program has been further tested and works well in the region where improper correction fails. The parts of the alternate computer program have been written and are being tested; the smoothing technique appears to operate satisfactorily. Additional experimental and analytic work was conducted.

2.0 PROGRESS REPORT ON ACTIVITY DURING MARCH BY TASK

2.1 EXPERIMENTAL PROGRESS

2.1.1 Noise Addition Experiment

This experiment concerns the mathmatical addition of random noise to edges to test hand smoothing. There has been little effort on this task during the past month. The noisy edges have been smoothed and are being analyzed. The continuation of this aspect of the program will depend on nature of the initial results. A question exists as to whether or not we are adding sufficient noise to constitute a meaningful experiment.

2.1.2 Verification With Sine Wave Target Measurements

This effort is directed towards establishing the reliability of the edge gradient technique by comparison to sine wave target measurements. Work is proceeding according to schedule toward a May completion date.

2.1.3 Effect of Exposure Level Contract and Granularity

An experimental determination of the effects of different characteristic curves, exposure levels, contrasts and granularity levels on our ability to measure the MTF is presently in progress. Experiments dealing with the effects of the characteristic curves and the exposure levels have been completed. The results are now being examined. The contrast level experiment will be completed shortly with the granularity level portion of the program beginning immediately thereafter.

2.1.4 Installation of the Digital Equipment

The digitizing-tape-punch equipment has been installed on the microdensitometer. The equipment has been tested and found to operate satisfactorily. The microdensitometer can now be used to obtain an analog and digital output. The digital output is being used to test various parts of the new computational program which is under development.

2.2 REFINEMENTS IN COMPUTATION

2.2.1 Tests of the Microdensitometer Correction Program

In edge gradient analysis, the correction for the microdensitometer must be made on the transmission side of the sensitometric curve. A computer program, which makes the correction in the proper manner, was developed and reported in the previous report. In addition, the previous report showed that large errors can result from the improper method of correction. Figure 1 shows the extent of such errors for four of the cases examined. The degraded edges, corresponding to these cases, were used as inputs to the correction program. The corrected edges from the program and the true analytic edges are plotted in figures 2 through 5; the results show exact agreement. As could be expected from the edge plots, the modulation transfer functions for the corrected edges and the true edge are in perfect agreement. As a result of these tests and other test cases, it is evident that the program works very well in the region where improper correction fails.

2.2.2 Development of an Alternate Method of Computation

In order to make full use of the output of a digitized microdensitometer an alternate computational program for edge gradient analysis is being developed. A brief description of the program was given in the previous report. The main portions of the procedure have been programmed and are being tested separately before they are assembled to form the computer program. The heart of this program, the smoothing procedure has been found to work satisfactorily. The test has been made of convolving an edge with the function: $\frac{\sin 2\pi K_c X}{2\pi K_c X}$. This results in cutting off all noise of frequencies higher than K_c. (Note that K_c must be higher than the cut-off frequency for the edge's modulation transfer function.) An example of a noisy edge obtained as a digitized output which has been smoothed by this method is given in figure 6. (This case corresponds to a low frequency edge with a modulation cut-off at about 12 cycles per millimeter, a digitized output taken at an interval of 3.32 millimeters, and a cut-off frequency for smoothing of 15 cycles per millimeter. This plot was obtained from an online plotter using all of the points; to obtain the modulation transfer function of the edge, only a fraction of these points need be used.) Since the smoothing technique performs satisfactorily, the development of a new computational program appears certain.

2.2.3 Method for Edge Correction

Previously, a procedure was developed to obtain an exact correction when an edge of known curvature was scanned and used for edge gradient analysis. A method has been developed which allows the present microdensitometer correction program to be used to also correct for edge curvature. A small study into the effects of edge curvature is being conducted to determine when it is necessary to perform the curvature correction.

3.0 ACTIVITY FOR THE NEXT PERIOD

During the next period work will continue on providing experimental verification of the edge gradient technique by comparison with sine wave target measurements and reproducibility of edge gradient results for varying exposure level, contrast, and granularity.

Also an effort will be made to complete the development of the computer program designed to use noisy digitized input data.

In addition a report on "Crossover" will be submitted by April 20.

STATINTL

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RJ/cam

FIGURE 1.

M.T.F. OF CAMERA-ATMOSPHERE SYSTEM OBTAINED BY IMPROPER CORRECTION FOR THE MICRODENSITOMETER

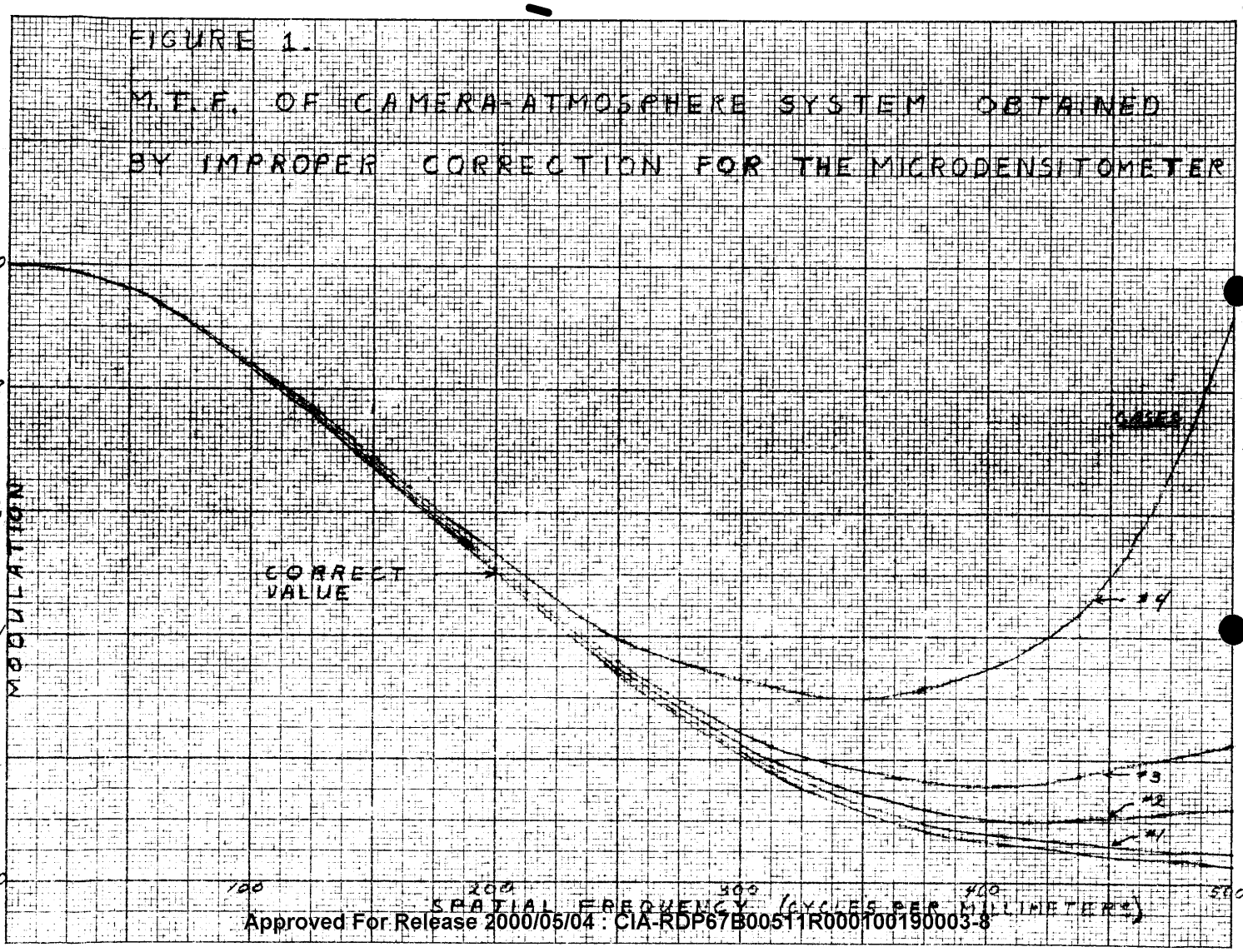


FIGURE 2.

COMPARISON - CORRECTED EDGE AND TRUE EDGE

CASE 4
$\varepsilon = 24.52$
$\mu = 2.63$

PROGRAM CORRECTED EDGE
ANALYTIC CORRECTED EDGE

TRANSMISSION

.115
.11
.107
.105

.03 MICRON

FIGURE 3.

COMPARISON - CORRECTED EDGE AND TRUE EDGE

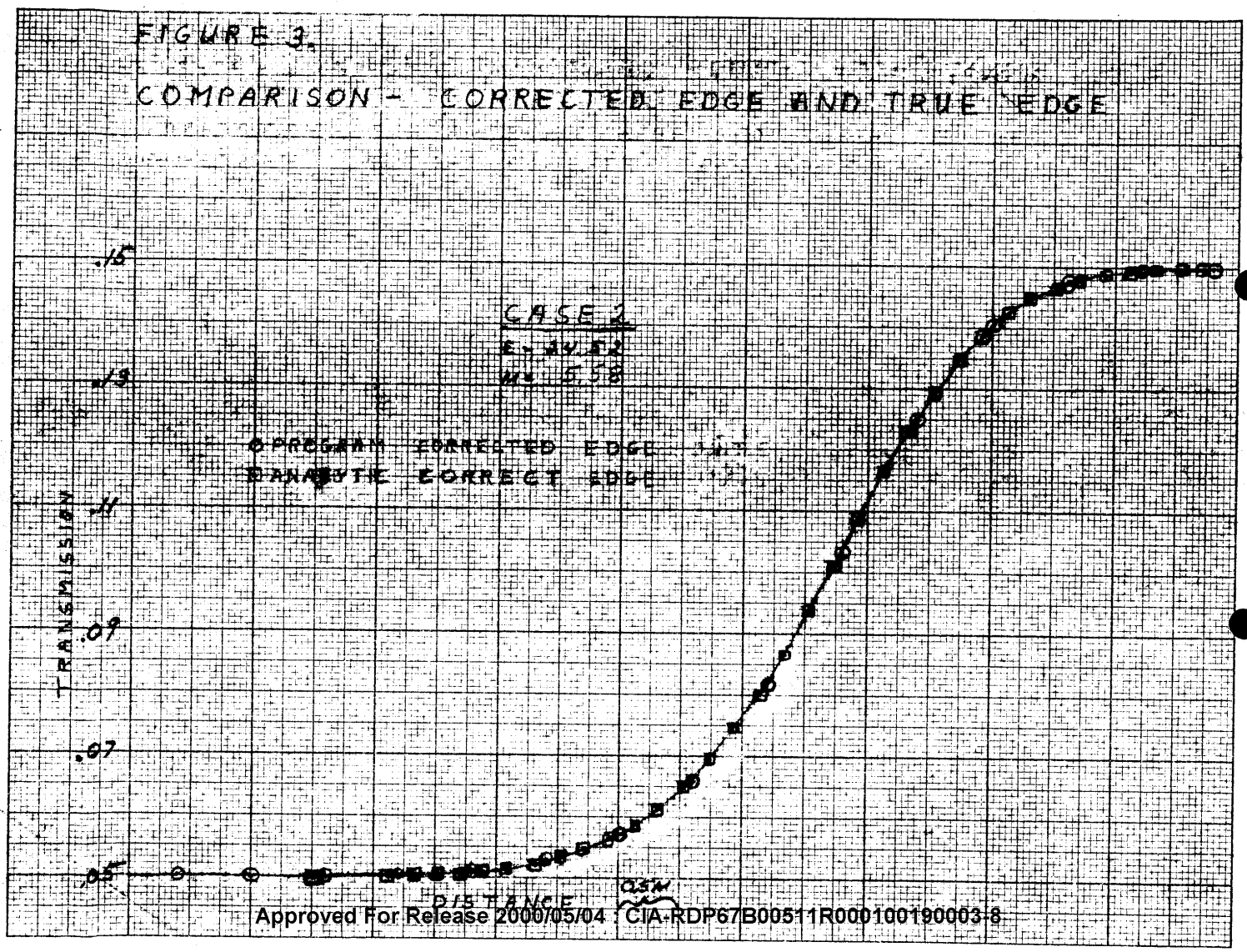


FIGURE 4.

COMPARISON - CORRECTED EDGE AND TRUE EDGE

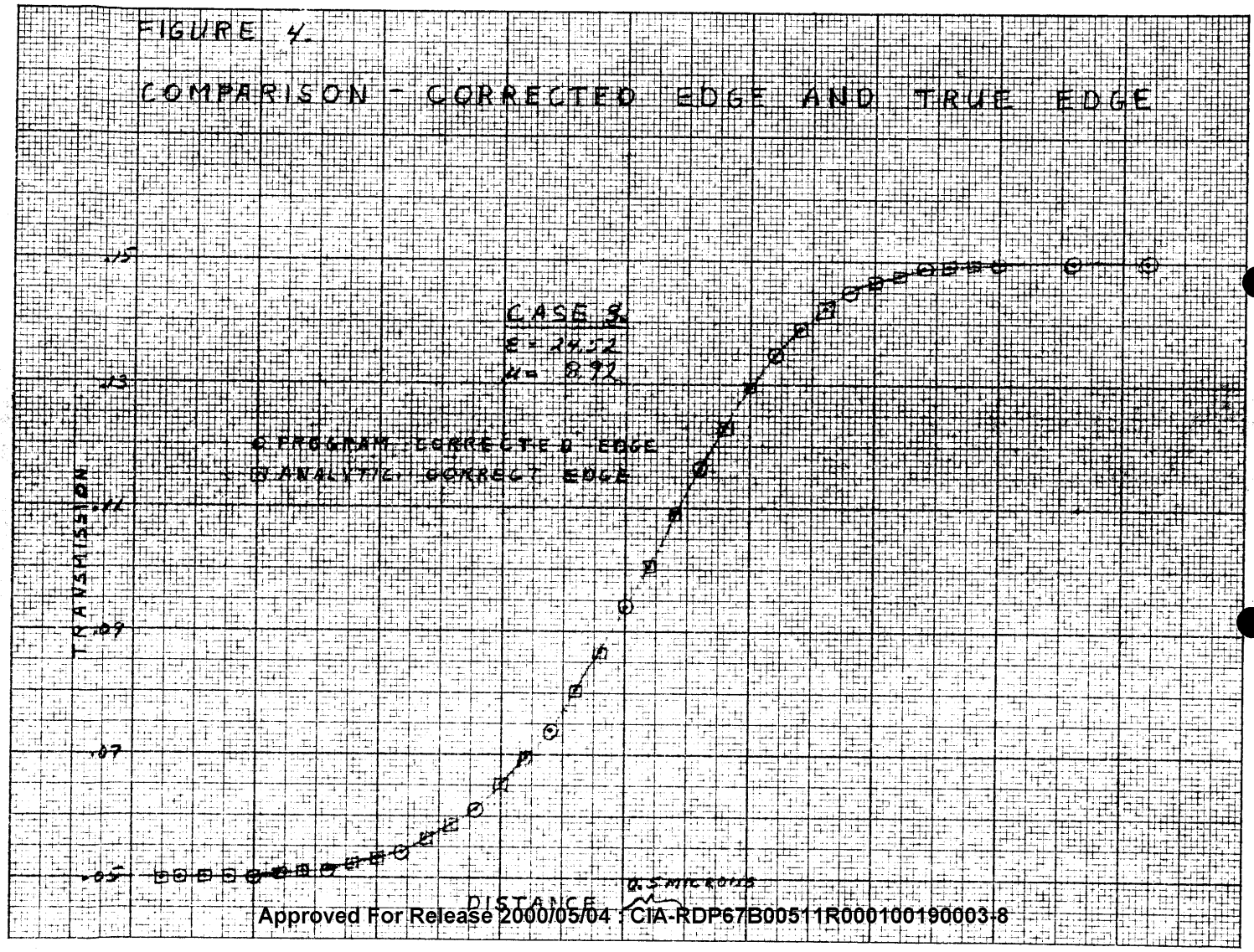


FIGURE 5.

COMPARISON - CORRECTED EDGE AND TRUE EDGE

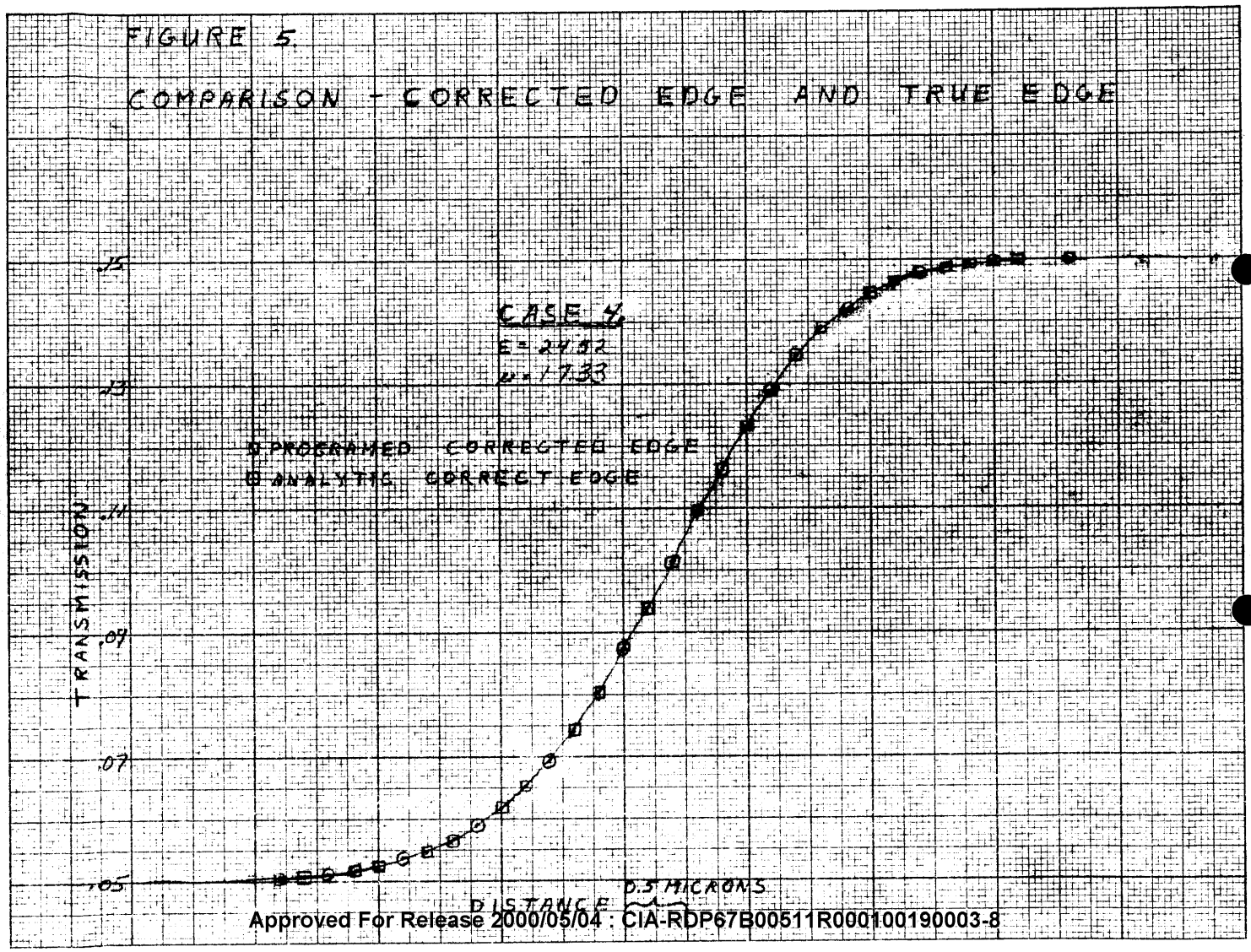
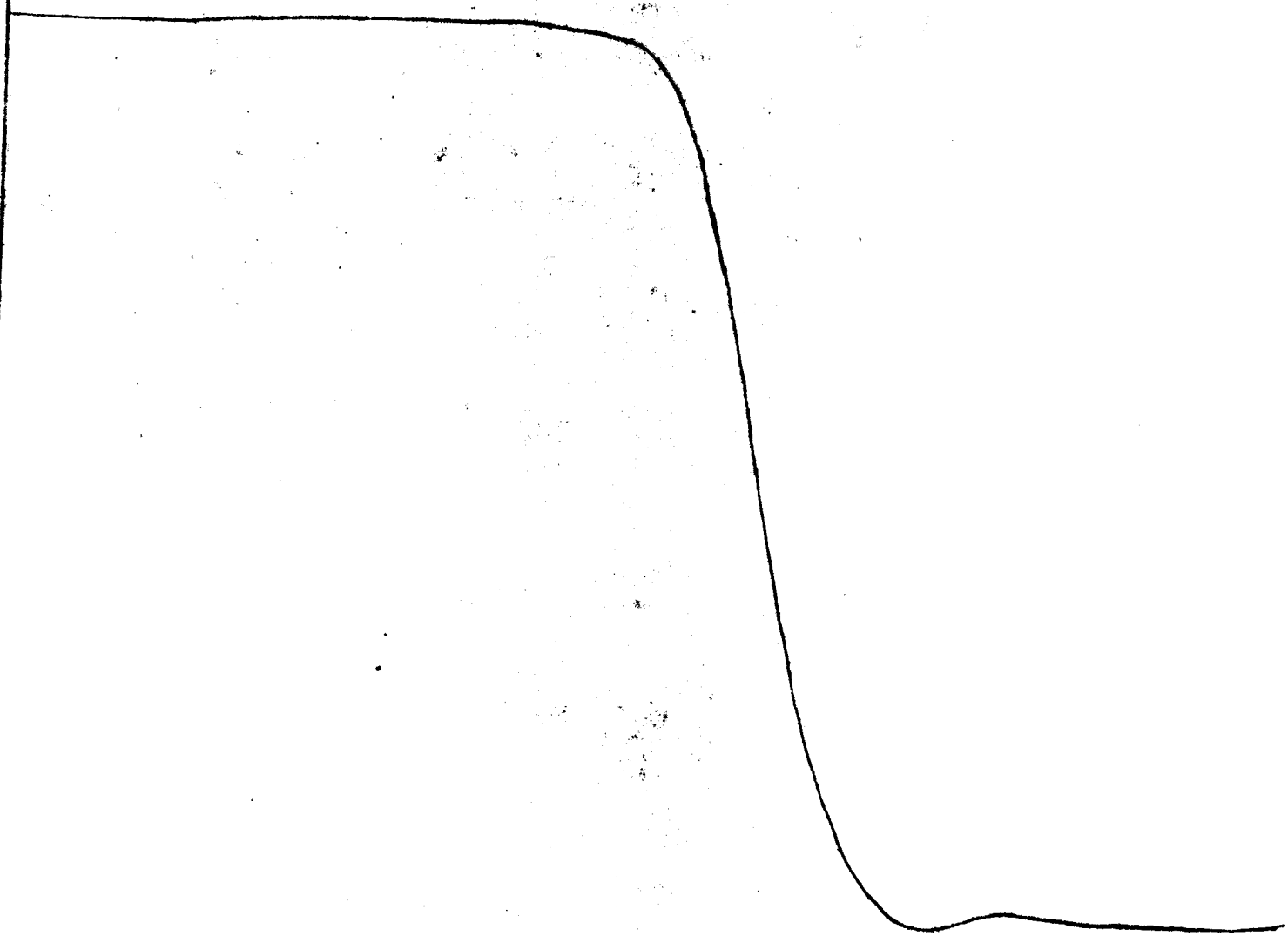


FIGURE 6



EXAMPLE OF SMOOTHING
A NOISY EDGE